REVOLUTIONIZING AGRICULTURE OPERATION THROUGH SOLAR ENERGY– AN ANALYTICAL STUDY

Synopsis

Submitted in the partial fulfilment for the requirement of

Doctor of Philosophy

In

Applied Business Economics

Submitted by

Kamini Singhal

Under the supervision

Prof. Shalini Dubey

DEPT. OF APPLIED BUSINESS ECONOMICS, FACULTY OF COMMERCE

DAYALBAGH EDUCATIONAL INSTITUTE (DEEMED UNIVERSITY)

DAYALBAGH AGRA -282005

2022

1. Introduction

Energy is basic need for economic growth of the country. Every sub district like agriculture, industry, transportation, commercial, and domestic – wants energy in numerous procedures. With fast growths taking place, ingesting of energy in all forms has continued progressively raising all ended the country. This growing ingesting of energy has also caused in the country becoming progressively reliant on fossil fuels such as coal, oil and gas. The frameworks of all these are reducing rapidly and prices of oil and gas are increasing. India's power sector has a entire connected volume of about 1,46,753 Megawatt (MW) of which 54% is coal-based, 25% hydro, 8% is renewable and the balance is the air and nuclear-based (REN21, 2009).

The adequate and secured energy supply is wanted to sustain financial growth. Augmented usage of fossil fuels causes ecological problems both locally and internationally. Worldwide boiler is one of the thoughtful bi-product of uncontrolled use of these fuels. Altering life style is resulting in increased electricity ingesting. Against this background, the country immediately needs to promote energy upkeep and increase use of Non-conventional and Renewable Bases of Energy. Renewable energy bases are those where source from energy is transformed is natural and is resulting from natural procedures that are replenished continually.

The global financial slowdown has created an impact in energy market. The demand for the energy decreased during the economic recession, but demand for the energy has increased again with the pace of economic recovery. In the World Energy report at the 15th conference of parties (COP) to the United Nations Framework Conference on Climate Change (UNFCCC) in Copenhagen in December 2009 expressed the GHGs(Green House Gases) emission is the concern due to increasing demand for energy and the need for a truly sustainable energy path. Households and businesses are largely responsible for such an initiative, with a focused policy initiation. One such an initiative at the micro level individuals can contribute for a sustainable energy path is the consumption of Non-conventional Energy resources like solar energy, the freely available energy source for all the nations on the globe. The Ministry of Non-Conventional Energy Sources has been continuously implementing programmes for the development and utilization of available renewable energy sources in the country. As a result of efforts number of technologies and devices have been developed and have become commercially

available. These include biogas plants, solar water heater, different types of solar cookers, solar lanterns, solar street lights, solar pumps, wind generators, water-pumping wind mills, biomass gasifier and small hydro-electric generators. Renewable sources already contribute to about 5% of the total power generating capacity in the country.

2. RENEWABLE ENERGY SYSTEM

Renewable energy-such as solar, wind, and biofuels can play a key role in creating a clean, reliable energy future. The benefits are many and varied, including a cleaner environment. Electricity is often produced by burning fossil fuels such as oil, coal, and natural gas. The combustion of these fuels releases a variety of pollutants into the atmosphere, such as carbon dioxide (CO2), sulfur dioxide (SO2), and nitrogen oxide (NO2), which create acid rain and smog. Carbon dioxide from burning fossil fuels is a significant component of greenhouse gas emissions. These emissions could significantly alter the world's environment and contribute to global warming (Svejkovsky, 2006).

Renewable energy, on the other hand can be a clean energy resource. Using renewables to replace conventional fossil fuels can prevent the release of pollutants into the atmosphere and help combat global warming. For example, using solar energy to supply a million homes with energy would reduce Co2 emissions by 4.3 million tons per year, the equivalent of removing 850,000 cars from the road (Svejkovsky, 2006). Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (natural replenished). In 2006, about 18% of global fuel energy consumption came from renewables, with 13% coming from traditional biomass, which is mainly used for heating, and 3% from hydroelectricity. New renewables (small hydro, modern biomass, wind, solar, geothermal, bio-fuels) accounted for another 2.4% and are growing very rapidly. The share of renewables in electricity generators is around 18%, with 15% of global electricity coming from hydroelectricity and 3.4% from new renewable (Wikipedia, 2009). This paper thus outlines some applications of solar energy technologies used in agriculture.

3. The solar market today

There are nearly 103 gigawatts (GW) of solar installed in the U.S., enough to power 18.6 million homes. Over the last decade, the solar market in the United States has grown at an average rate of 42% each year. There are more than 2.9 million individual solar installations in the U.S., ranging from

small home rooftop systems to large utility-scale systems that add hundreds of megawatts of clean electricity to the power grid.

4. Solar Energy in India

India, a rapidly growing economy with more than 1 billion people, is facing a huge energy demand. The country stands fifth in the world in the production and consumption of electricity. The electricity production has expanded over the years but we cannot deny the fact that the population of the country is also expanding. The power produced in the country is mostly from coal (53%) and it is predicted that country's coal reserves won't last beyond 2040-50. More than 72% population living in villages and half of the villages remain without electricity. It's high time that our country should concentrate more on energy efficiency, conservation and renewable energy. To meet this surging demand, solar energy is the best form of energy to fulfill the energy needs of India and bridge the energy demand-supply gap.

India has tremendous scope of generating solar energy. The geographical location of the country stands to its benefit for generating solar energy. The reason being India is a tropical country and it receives solar radiation almost throughout the year, which amounts to 3,000 hours of sunshine. This is equal to more than 5,000 trillion kWh. Almost all parts of India receive 4-7 kWh of solar radiation per sq metres. This is equivalent to 2,300–3,200 sunshine hours per year. States like Andhra Pradesh, Bihar, Gujarat, Haryana, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, and West Bengal have great potential for tapping solar energy due to their location. Since majority of the population lives in rural areas, there is much scope for solar energy being promoted in these areas. Use of solar energy can reduce the use of firewood and dung cakes by rural household.

4.1 Advantages of Solar Energy in India

Some of the advantages of solar energy which makes it all the more suitable for India are as follows:

1. This is an inexhaustible source of energy and the best replacement to other non-renewable energies in India.

2. Solar energy is environment friendly. When in use, it does not release CO2 and other gases which pollute the air. Hence it is very suitable for India, India being one of the most polluted countries of the world.

3. Solar energy can be used for variety of purposes like as heating, drying, cooking or electricity, which is suitable for the rural areas in India. It can also be used in cars, planes, large power boats, satellites, calculators and many more such items, just apt for the urban population.

4. Solar power is inexhaustible. In an energy deficient country like India, where power generation is costly, solar energy is the best alternate means of power generation.

5. You don't need a power or gas grid to get solar energy. A solar energy system can be installed anywhere. Solar panels can be easily placed in houses. Hence, it is quite inexpensive compared to other sources of energy.

India is slowly gaining its prominence in the generation of solar power due to the comprehensive and ambitious state and the Centre's solar policies and projects and National Solar Mission. In the latest 2014 budget, Finance Minister Jaitley declared that the Government has proposed an amount of 500 crore rupees to develop some mega solar power plants in Gujarat, Tamil Nadu, Rajasthan, and Ladakh. He also said that solar power-driven agricultural water pumping stations and 1 MW solar parks on canal banks will be developed in the country at an estimated cost of $74 million and $18.5 million, respectively. Considering all these facts, we do have a bright picture in front of us as India's potential to be a solar power driven country of the world.

5. Significance of solar energy

The Significance of Renewable Energy In India. In recent years, across India, the role of solar and other renewable energy sources has increasingly become more prominent. India has become globally the lowest cost producer of solar power, after reaching their 20 GW capacity target for 2022, four years ahead of schedule. Despite the fact that coal has been dominating its energy market for a number of years, the country has decided to phase out fossil-based energy generation and adopt green energy. India has a strong incentive to develop new, domestic energy sources, reducing its trade deficit.

The growth of solar energy in emerging markets throughout India has been exceptional, with the nation already overtaking the US and becoming the second largest solar power market in the world. They are continuing to develop the electricity with solar power projects in Tamil Nadu, Rajasthan, Gujarat and Maharashtra, also being the top five states in India with the highest wind electricity generation.

Why is solar energy becoming so popular in India?

Solar and wind were once considered a costly source of power, but when compared to other conventional forms of energy, they are actually much more cost effective. The solar power plants are also relatively easy to maintain, without emitting any polluting gases. When utilised in countries like India, the simplicity of this technology makes it ideal for use in rural or difficultly accessed areas isolated from the network.

In rural India, renewable energy has the ability to bring electricity to remote places where people have not had access or not enough of it. Solar panels in India have the ability to changes lives for the better and it contributes economic benefits. The only limitation of solar power is our ability to turn it into electricity in an efficient and cost-effective way. With its pollution free nature, virtually inexhaustible supply and global distribution – solar energy is a very attractive energy resource for many countries across the globe.

Four fact sheets on renewable energy and agriculture are now available for farmers and clean energy advocates, giving valuable information on renewable energy technologies and the rural economic development opportunities they could create.

Many farmers already produce renewable energy by growing corn to make ethanol. An increasing number of farmers and ranchers are now adding to their incomes by harvesting the wind that blows across their land to make electricity. And new options are becoming available.

Renewable energy and farming are a winning combination. Wind, solar, and biomass energy can be harvested forever, providing farmers with a long-term source of income. Renewable energy can be used on the farm to replace other fuels or sold as a "cash crop."

Wind energy alone could provide 80,000 new jobs and $1.2 billion in new income for farmers and rural landowners by 2020, according to the U.S. Department of Energy. Renewable energy can also help reduce pollution, global warming, and dependence on imported fuels. This leaflet describes renewable energy options for farmers and ranchers and how they can help make renewables a growing source of energy and rural income in the United States. Other leaflets describe solar, wind, and biomass energy in more detail.

India is an agriculture-based country, where the agriculture sector provides livelihood to two-thirds of the total working population and contributes to 15% of the Gross Domestic Product (GDP). India's favourable agro-climatic conditions make it as one of the top producers of cereals, pulses, fruits, vegetables, milk, meat and fish and hence it also occupies the 7th position as net exporter, across the globe. Since the adoption of Green Revolution in the 1960s, there has been a 45% increase in per person food production in the country.

6. **Agricultural Application of Solar Energy**

Solar energy can supply and or supplement many farm energy requirements. The following is a brief discussion of a few applications of solar energy technologies in agriculture.

6.1 Crop and Grain drying

Using the sun to dry crops and grain is one of the oldest and mostly widely used applications of solar energy. The simplest and least expensive techniques is to allow crops to dry naturally in the field, or to spread grain and fruit out in the sun after harvesting. The disadvantage of these methods is that the crops and grains are subject to damage by birds, rodents, wind, and rain, and contamination by wind blown dust and dirt. More sophisticated solar dryers protect grain and fruit, reduce losses, dry faster and more uniformly, and produce a better quality product than open air methods (EREC, 2002; UCS, 2009).

The basic components of a solar dryer are an enclosure or shed, screened drying trays or racks, and a solar collector. In hot, arid climates, the collector may not even be necessary. The southern side of the enclosure itself can be glazed to allow sunlight to dry the material. The collector can be as simple as a glazed box with a dark coloured interior to absorb the solar energy that heats air. The air heated in the solar collector moves, either by natural convection or forced by a fan, up through the material being dried. The size of the collector and rate of airflow depends on the amount of material being dried, the moisture content of the material, the humidity in the air, and the average amount of solar radiation available during the drying season (Schepens, 1986).

There is a relatively small number of large solar crop dryers around the world. This is because the cost of the solar collector can be high, and drying rates are not as controllable as they are with natural gas or propane powered dryers.

Using the collector at other times of the year, such as for heating farm building, may make a solar dryer more cost effective. It is possible to make small, very low cost dryers out of simple materials. These systems can be useful for drying vegetables and fruit for home use (NYSERDA, 2009).

6.2 Space and Water Heating

Livestock and diary operations often have substantial air and water heating requirements. Modern pig and poultry farms raise animals in enclosed buildings, where it is necessary to carefully control temperature and air quality to maximize the health and growth of the animals. These facilities need to replace the indoor air regularly to remove moisture, toxic gases odors, and dust. Heating this air, when necessary, requires large amount of energy. With proper planning and design solar air/space heaters can be incorporated into farm buildings to preheat incoming fresh air.

6.3 Greenhouse Heating

Another agricultural application of solar energy is greenhouse heating. Commercial green house typically rely on the sun to supply their lighting needs, but are not designed to use the sun for heating. They rely on gas or oil heaters to maintain the temperatures necessary to grow plants in the colder months. Solar greenhouse, however are designed to utilize solar energy both for heating and lighting.

6.4 Remote Electricity Supply (PHOTOVOLTAIC)

Solar electric, or photovoltaic (PV), systems convert sun light directly to electricity. They work any time the sun is shining, but more electricity is produced when they sun light is more intensive and strikes the PV modules directly (as when rays of sunlight are perpendicular to the PV modules). They can also power an electrical appliance directly, or store solar energy in a battery. In areas with no utility lines, PV systems are often cheaper and require less maintenance than diesel generators, wind turbines, or batteries alone. And where utilities charge for new lines, a PV generating system is often much cheaper for the land owner than paying for a new line.

6.5 Water Pumping

Photovoltaic (PV) water pumping systems may be the most cost-effective water pumping option in locations where there is no existing power line. They are exceptionally well suited for grazing operations to supply water to remote pastures. Simple PV power systems run pumps directly when the sun is shining, so they work hardest in the hot summer months when they are needed most. Generally,

batteries are not necessary because the water is stored in tanks or pumped to fields and used in the day time.

7. **Solar Power Value Chain**

It is a well-known fact that value addition in agricultural and dairy products causes multi-fold increase in the profitability. Most of the farmers do not have the value chain because of lack of reliable electricity. Design and development of solar powered machinery viz. electric thrashers, electric boilers for milk pasteurization, DC compressor based efficient chiller/cold storage etc. is envisaged to complete the demonstration setup. Solar powered value chain will further increase the profit margin for the farmers.

National and International review of literature-

A literature review is an account of what has been published on a topic by accredited scholars and researchers. In writing the literature review, our purpose is to convey what knowledge and ideas have been established on the above mentioned topic, and what are their strengths and weakness.

1. **Bart Van Campen (2000),"**Solar photovoltaics for sustainable development and rural development", Solar Home Systems (SHS) are still the dominant PV application in rural areas of developing countries and their main use is for lighting and radio/TV in households. The evidence of the impact of SHSs on household economics is mixed: some studies report that there is little evidence of such direct impacts; others make reference to time savings and extension of the day due to SHSs. This "surplus time" is sometimes used for productive activities such as sewing, basket weaving and handicraft making.
2. **S. Ali. (2004)** , "Total factor productivity growth in Pakistan's agriculture: 1960-1996." This study evaluated the TFP growth in Pakistan's agriculture during 1960-96 using Tornqvist-Theil Index (TTI) approach. The results showed that agriculture productivity was much higher during the second half of the 1960s mainly due to the introduction of high yielding varieties of rice and wheat during this period. The growth in productivity tapered off in the first half of the 1970s due mainly to the politically induced institutional experiments. Gradual recovery in productivity growth was observed in the late 1970s and early 1980s. Annual TFP growth of 2.4 percent had been sustained during the period

3. **Ali (2005)** "Total Factor Productivity Growth and Agricultural Research and Extension: An Empirical Analysis for Pakistan's Agriculture, 1960-96, Pakistan Development Review" This study analysed the impact of Research and Extension (R&E) investment on TFP growth Pakistan during the period 1960-96 within a distributed lag framework. The estimation of the productivity-R&E relationship provided evidence of a strong relationship, explaining 96 percent of the variation in TFP index. The marginal internal rate of return on R&E investment is estimated at 88 percent.
4. **A. K. Kiani (2008)**, "Total Factor Productivity and Agricultural Research Relationship: Evidence from Crops Sub-Sector of Pakistan's Punjab" The substantial gains in productivity have underpinned a strong performance of crops sub-sector in Punjab since the 1970s. Apparently, investment in agricultural research has played an important part in productivity growth. Mechanization and development of roads infrastructure also have positive significant effect on TFP.
5. **Arias, D.A., McMahan, A.C., and Klein S.A.(2008),** Sensitivity of long term performance simulations of solar energy system to the degree of stratification in the thermal storage unit. To performance simulations of solar energy system. A relatively smaller number of nodes such as five for a water storage tank are needed to simulate the annual performance of a solar system accurately.
6. **Hobbi, A., and Siddiqui, K. (2009),** Experimental study on the effect of heat transfer enhancement devices in flat- plate solar collectors The effect of different passive heat tranfer enhancement techniques inside flate-plate solar energy. A comparison of the twisted strip, coil-spring wire and sharp ridges.
7. **Pradeep S. Chauhan (2009)** Energy and climate change issue of sustainable development.To study the renewable energy consits of energy produced. The trend is driven more by increased energy consumption than a particular focus on renewable energy.
8. **Ahamad Asyraf Bin Ramli (2010)** Theoretical analysis of solar water heating system. To study the solar energy to reduce environment friendly. Solar energy can be used as a clean alternative energy to reduce electricity production and is promising in effect to establish environmentally friendly.

9. **Ramesh khanna (2010)** Solar panel power two-stage lead acid battery changer. To study solar panel powering two-stage lead-acid battery charger. A solar cell has limited current generating and carrying capability which results in the limited current carrying ability of the entire solar panel.
10. **Michaelides, L.M., and Eleftheriou, P.C. (2011)** An experimental investigation of the performance boundaries of a solar water heating system. To study the temperature stratification in the storage tank. SWHs by way of design modification and changes in operation variable.
11. **Mondol, J.D., Smyth, M., and Zacharopoulos,A. (2011)** Experimental Characterisation of a novel heat exchange for a solar hot water appliction under indoor and outdoor Condition. To study the operating performance of a different heat exchange. The hot fluid from the solar collector enters the solasyphon through the primary flow pipes.
12. **Dhanabhakyam, M., and Sumathi (2012)** The study on awareness of solar energy production in house hold Coimbatore To study electricity problem boon for humans. Solar energy is freely available right for the environment and easy to repair.
13. **Saidur, R.et al. (2012)** Energy analysis of solar energy applications. Renewable and Sustainable energy reviews To know study the thermal efficiency of solar energy. The energy efficiency of solar system depend heavily on the daily solar radiation and radiation intensity.
14. **S.M. Ali, N. Dash and A. Pradhan. (2012)**, "Role of Renewable Energy on Agriculture", The only realistic solution to the problem go non-renewable is to find sources of renewable energy to replace today's dwindling supplies of affordable and usable fossil energy. Solar energy is the only source of truly renewable energy – renewable at least for the next few billion years. Windmills, falling water, solar collectors, and photovoltaic cells are all sources of renewable solar energy. The most common solar energy collectors are green plants renewable energy on agriculture." International
15. **Keskar Vinaya N (2013**) Electricity Generation Using Solar Power To know the uses of the solar energy. The solar panel is aligned according to the intensity of sunlight under the control of microcontroller.

16. **Sandeep Kumar Gupta,(2013)** Development of Solar Electricity Supply System in India: An Overview To know the development under the state policy. National Solar Mission performance and enhance the overall visibility of solar-based electricity generation and utilization.
17. **Sharma Pragya(2013**),"Solar energy generation potential along national highways", In this study, we have suggested, first time ever of itskind, an approach to utilize solar energy to meet the global challenges like climate change, pollution, and en-ergy insecurity and also to address the biggest chal-lenge for the photovoltaic technology, i.e., land cost.Indian roads are paying a very vital role in the economythrough transportation, whose share has been increasedbefore 2000 only to 60% in total sharing of 40% with railways . This means that efficiency of the vehicle and life of the road are equally important. Through this paper, we are also answering some of these issues. It is well known that the availability of land is becoming more expensive and also becoming a rare commodity.
18. **Venkatraman, M. and Sheeba,U. (2014)** A study on customer's attitude toward solar energy devices To study the consumer attitude toward solar energy devices. The customerhave becom more concious about saving power and switching on to other source of power like solar energy for their consumption.
19. **Agrawal,S., and A.Jain.(2016)** "Sustainable of Solar -based Irrigation in India. Key Determinants , Challenges and Solutions," The use of solar energy on farmland shows a diversity of approaches that address objectives such as renewable dissemination, water use efficiency or agricultural productivity. The SEF experience from Jordon and India seek to partially or completely substitute agriculture production with solar farming activities, in an effort to reduce water abstractions.
20. **V.T.Mohammad , H.M. Atefeh (2017)**, " The Application of Solar Energy in Agricultural Systems", The solar energy can be found in the farthest corners of the world and it can be developed to electric power production and agriculture. Using solar energy can do the majority of cases related to agriculture. In addition, due to the reduction fossil fuel energy can inexpensively Gremlin. Also uses solar energy in agriculture can land that is unusable into the greenhouse or shed for breeding animals converted in areas outside city. On foregoing, the use of solar energy is an investment for the future because we can use it for a long time. In

addition, a company can use this method to create, build panels and install them. This creates jobs and helps the economy.

21. **Saddam Ansari, Anup Kumar, Deepak Garg (2020)** Investigation on Fundamentals of Solar Energy To study the main barriers to widespread use.It needs massive additions in capacity to meet the demand of its rapidly growing economy.
22. **Shrivastava Vikas (2021)** , "A Review on Future Technology Development on Solar Power of Agriculture, Residential and Industrial" This study explored the efficiency of creating energy in atypical in industrial and residential and agriculture. The use of the solar panels system on a wide range can lead to a considerate energy saving way for the challenges facing governments, especially in the developing world. It is highly recommended to implement further future research on the economics and design potentials associated with the spread of the system.
23. **Pascaris Alexis(2021)**, "Integrating Solar Energy with agriculture: Industry perspectives on the market, community, and socio-political dimensions of agrivoltaics" To address global demands for both food and energy, the relationship between critical land uses must become complementary rather than competitive. Because social acceptance of renewable energy technology is pivotal to energy transitions, this study reflects a proactive attempt to understand agrivoltaics from a solar industry professional's perspective to better understand the significant opportunities and barriers to development.
24. **Y. Farja., M. Maciejczak (2021),"**Economic Implications of Agriculture Land Conversion to Solar Power Production" Global actions towards more sustainable energy production from renewable source form a movement that can already be recognized as an energy revolutions. This revolutions is significant from the scope of changes but relatively slow from the perspective of their implementation.

Research Gap :-

After going through reviews of literatures it has been analyzed that majority of the studies have been done with the objectives of Environmental impact, trends of sells of solar equipment, climate etc. but no study talks about

(i) Government policies

(ii) Replacement of traditional energy by solar energy and

(iii) Its impact on farmers income

Which are taken as the objectives of our study.

Need of the study:-

Energy is one of the major parameters for establishing growth and progress of the country, rather the standard of living depends directly upon the per capita energy consumption. Use of renewable energy in farming systems can mean several different things. For example, fossil fuels such as oil are non-renewable, so finding alternative ways of fertilising the land and controlling pests that do not depend on chemicals, will normally involve the use of renewable resources. Such methods reduce farmers' vulnerability to the rising price of oil. Renewable energy also includes generation of power to do a number of farm tasks: pumping water for irrigation, for livestock or for domestic use; lighting farm buildings; powering processing operations and others. These forms of renewable energy include solar energy, wind and water power, oil from plants, wood from sustainable sources, other forms of biomass (plant material), and biogas (gas produced from fermentation of manure and crop residues).

Most of energy on the earth is received from the sun. Solar energy creates circulation of wind and ocean water, causes water evaporation and consequent precipitation. Plants use solar energy for photosynthesis and store carbohydrates, protein, fats, oils, alcohols, cellulose and lignin.. In agricultural systems, energy is available from different sources as human, animal, sun, wind, biomass, coal, fertilizer, seed, agro-chemicals, petroleum products, electricity etc. Solar energy is the only source of truly renewable energy – renewable at least for the next few billion years. Windmills, falling water, solar collectors, and photovoltaic cells are all sources of renewable solar energy. The most common solar energy collectors are green plants. After all, plants were the original collectors of today's fossil energy. So, it's only logical to look to agriculture as a renewable source of alternative energy for the future. However, we need to be realistic about the extent to which energy from agriculture can replace our current use of fossil energy. While the energy experts may not agree on specific quantities or percentages, the overall limits on energy from agriculture are fairly basic and straightforward. Solar energy directly to the system are classified as direct energy sources. Wind,

solar, and biomass energy can be harvested forever, providing farmers with a long-term source of income.

Objective of the study:-

1. To study the Government policy for agriculture and use of solar energy in agriculture operation.

2. To study the present status of solar farming in Agra district

3. To find out challenges/issue use of solar energy in agriculture operation.

4. To analyze the impact of uses of solar energy in agriculture operation/activities on farmer's income.

5. To identify agriculture operation where traditional energy source may be replaced by solar energy.

6. To suggest the Action plan/model to promote and enhancing the solar farming in Agra district.

Table 1: Research design adopted

S.no	Parameters	Description
1.	Research design	Analytical Study
2.	Sample method	Convenient sampling method
3.	Sample size	278 respondents
4.	Sample Element	Respondents (solar power user farmers)
5.	Sample area	Agra district
6.	Sample unit	Agra district rural area
7.	Research approach	Website, books, journals ,thesis , newspaper, publishers etc.
8.	Research instrument and contact method	Questionnaire or schedule filled through personal visit to krishi dept. and farmers .
9.	Data collection	Primary and Secondary data
10.	Data analysis	Descriptive & Inferential statistics

Duration of the study: A period of time (2015-23) will be taken into consideration for the study purpose.

Sample Size and Selection Criteria-

Table 2: Selection of the Sample:-

S.no	Tehsil wise name	Respondents Farmers
1.	Bah	91
2.	Fatehabad	49
3.	Kheragarh	45
4.	Kiraoli	25
5.	Agra Sadar	20
6.	Etmadpur	58
	Total	278 (Total no availability krishi dept. and farmers).

Sampling Design: This study is based on farmers using Solar Energy in Agriculture operation in Agra District.

Sample Size: 278 farmers (from Krishi dept.and farmers) using solar energy for agriculture operation shall be sample for the study. More farmer using solar energy for agriculture operation may be studied during the course of Research.

Sampling Techniques: For the purpose of the study, convenient sampling technique will be used. In convenience sampling technique, on the basis of the researcher's convenience, sample is selected which is considered as representative of the population. So in this case on the basis of the researchers judgment sample will be selected.

Collection of Data (Methods of data collection)

Primary data: Primary data will be used in this study. Primary data is the data which is collected for the first time by the Research. It will be collected by using well-structured interview, questionnaire, and schedule.

Secondary Data: Secondary data refers to the data which is originally collected and published by the authorities. It will be collected from books, websites and few journals and newspaper, magazines, internet and company reports and business journals.

Consolidation of Data

The collected data will be consolidated in the form of schedules for the purpose of interpretation, tabulation and formation of master table for analysis purpose. After the classification, the data will be processed (analysis) by using various statistical tools (SPSS) and diagrammatic illustration.

Specific Research Methodology:-

The researcher will be use the following Specific Research Methodology:

Table 3: Research Methodology

S. No.	Objectives	Data Collection Source	Statistical Tools
1.	To study the Government policy for agriculture and use of solar energy in agriculture operation.	For achieving this objective, the secondary data will be used.	Theoretical/ descriptive will be used for achieving this objective.
2.	To study the present status of solar farming in Agra district.	For achieving this objective, the primary data will be used.	ANOVA will be used for achieving this objective.

3.	To find out challenges/issue use of solar energy in agriculture operation.	For achieving this objective, the primary and secondary data will be used for framing well-structured questionnaire based on review of past studies.	Factor analysis technique and suitable test will be used according to data normality.
4.	To analyze the impact of uses of solar energy in agriculture operation/activities on farmer's income.	Data for this objective will be achieved through primary source with specific tools.	T-Test and ANOVA and Regression will be used for achieving this objective.
5.	To identify agriculture operation where traditional energy source may be replaced by solar energy.	This objective will be fulfilled by primary sources.	Factor analysis technique and suitable test will be used according to data normality.
6.	To suggest the action plan/model to promote and enhancing the solar farming in Agriculture.	This objective will be fulfilled by primary and secondary sources.	Diagrammatic will be used for achieving this objective.

Proposed Plan of the study:

Chapter-1: Introduction: Government policy for agriculture and use of solar energy in Agriculture Operation.

Chapter-2: Review of Literature and Research Methodology.

Chapter-3: Present status of agriculture operation using solar energy in Agra District.

Chapter-4: Analysis and Interpretation of data

Chapter-5: Finding, Conclusion and Suggestion

Reference and Bibliography

Annexure

Reference:-

1. Bart Van Campen (2000),"Solar photovoltaics for sustainable development and rural development", Environment and Natural Resources Working Paper No. 2 FAO, Rome, 2000

2. S. Ali. (2004) "Total factor productivity growth in Pakistan's agriculture: 1960-1996." Pakistan Institute of Development Economics, Islamabad . vol. 43, pp. 493-513, 2005.

3. Ali, S. (2005), "Total Factor Productivity Growth and Agricultural Research and Extension: An Empirical Analysis for Pakistan's Agriculture, 1960-96, Pakistan Development Review. 44:4 Part II, Pp. 729-746

4. A. K. Kiani (2008), "Total Factor Productivity and Agricultural Research Relationship: Evidence from Crops Sub-Sector of Pakistan's Punjab" European Journal of Scientific Research ISSN 1450-216X Vol.23 No.1 (2008), pp.87-97 .

5. Arias, D.A., McMahan, A.C., and Klein S.A. (2008) "Sensitivity of long term performance simulations of solar energy system to the degree of stratification in the thermal storage unit", International journal of energy and resource, Vol.32,pp.242-254.

6. Hobbi, A., and Siddiqui, K. (2009) "Experimental study on the effect of heat transfer enhancement devices in flat-plates solar collectors", International Journal of Heat and Mass Transfer, Vol.52,pp. 4650-4658.

7. Pradeep S. Chauhan (2009) "Energy and Climate Changes issue of Sustainable Development", The Associated Publicshers, Ambala Cantt, India.

8. Ahamad Asyraf Bin Ramli (2010) "Theoretical Analysis of solar water heating System ", Thesis of Bachelor of Mechanical Engineering, University Malaysia Pahang.

9. Ramesh Khanna (2010) "Solar Panel Power two-stage lead acid battery charges", EDN Europe, Vol.57(8).

10. Michaelides, L.M., and Eleftheriou, P.C. (2011) "An experimental investigation of the performace boundaries of a solar water heating system", Experimental Thermal and Fluid Science, Vol.35, pp. 1002-1009.

11. Mondol, J.D., Smyth, M., and Zacharopoulos,A.(2011) "Experimental Characterisation of a novel heat exchange for a solar hot water appliction under indoor and outdoor Condition", Renewable Energy, Vol.36,pp.1766-1779.

12. hanabhakyam,M., and Sumathi(2012) "The study on awareness of solar energy production in house hold coimbatore ", International Journal of Scientific Research, Vol. 1(1),pp.18-20.

13. Saidur, R.et al. (2012) "Energy analysis of solar energy applications. Renewable and Sustainable energy reviews", Vol.16,pp.350-356.

14. S.M. Ali, N. Dash and A. Pradhan. (2012), "Role of Renewable Energy on Agriculture", International Journal of Engineering Sciences & Emerging Technologies, vol. 4, Issue 1, pp. 51-57, Dec. 2012

15. Kevin bullis (2013) " Why more solar companies should fail", Technology Review, Vol.116(3),p.24.

16. Sandeep Kumar Gupta (2013) " Development of Solar Electricity Supply System in India: An Overview", International Research Journal of Business and Management Volume 2013 |Article ID 632364.

17. Sharma Pragya(2013),"Solar energy generation potential along national highways", International journal of Energy and Environmental Engineering , DOI : 10.1186/2251-6832-4-16.

18. Venkatraman, M. and Sheeba,U.(2014) " A study on customer's attitude toward solar energy devices", International Research Journal of Business and Management, Global Wisdom Research Publication, Vol.5, pp.53-57.

19. Agrawal,S., and A.Jain.(2016) "Sustainable of Solar -based Irrigation in India. Key Determinants , Challenges and Solutions," Accessed May 25,2018.

20. V.T.Mohammad , H.M. Atefeh (2017), " The Application of Solar Energy in Agricultural Systems" , Journal of Renewable Energy and Sustainable Development , Volume 3 Issue 2 ,ISSN 2356-8569.

21. Saddam Ansari, Anup Kumar, Deepak Garg(2020) " Investigation on Fundamentals of Solar Energy", July 2020 IJSDR | Volume 5, Issue 7.

22. Shrivastava Vikas (2021) , "A Review on Future Technology Development on Solar Power of Agriculture, Residential and Industrial" , International journal of Science, Engineering and Technology, ISSN: 2348-4098.

23. Pascaris Alexis(2021), "Integrating Solar Energy with agriculture: Industry perspectives on the market, community, and socio-political dimensions of agrivoltaics" , Energy Research &Social Science , Volume 75 102023.

24. Y. Farja., M. Maciejczak (2021),"Economic Implications of Agriculture Land Conversion to Solar Power Production" Energies 6063.